

THE SHAPE OF THE EARTH.¹

THE most promising suggestion towards a dynamical explanation of the distribution of land and water on the surface of the globe is to be found in the theory of gravitational instability: propounded by Jeans in 1903. There is always a tendency in gravitating matter, if homogeneous, to condense towards a centre, or towards an axis, or in some more complex fashion. If the matter is heterogeneous, there is always a tendency for the density to increase where it is above the average and to diminish where it is below the average. Such changes of density imply compression of the material, and they are resisted by the elastic force with which the material resists compression. In the case of a planet we may ask two questions: How small must the resistance to compression be in order that sensible condensations may take place? In respect of what changes of density can instability manifest itself? The answers depend greatly upon the size and mass of the planet, and they depend also upon its constitution.

Whatever the internal constitution of a planet may be, it is certain that, owing to the mutual gravitation of its parts, great stresses will be developed within it. A direct method of attacking the problem of gravitational instability for a planet in such a state of stress was proposed by Lord Rayleigh in 1906. The development of this method leads to the result that a homogeneous spherical planet, of the same size and mass as the earth, could not exist unless the resistance to compression of the material of which it is composed were at least half as great as that of steel. If the resistance were less than a quarter of that of steel (so that the substance was less compressible than mercury but more compressible than glass) such a planetary body would be unstable, both as regards concentration of mass towards the centre and also as regards displacements by which the density is increased in one hemisphere and diminished in the opposite hemisphere. No matter how small the resistance to compression might be, the body would not be unstable as regards any other type of displacements. If the resistance to compression were small enough for a spherically symmetrical state of aggregation to be unstable, the density of the superficial portions would be less than the mean density, and the centre of gravity would not coincide with the centre of figure. If the planet were at rest under no external forces, a shallow ocean resting upon it would be drawn permanently towards the side nearer the centre of gravity, so that there would be a land hemisphere and a water hemisphere.

The average resistance to compression of the materials of which the earth is composed can be deduced from the observed velocity of propagation of earthquake shocks, and it is found to be decidedly greater than that of any known material at the surface—a result clearly associated with the increase of resistance under great pressure. There is, therefore, no tendency to gravitational instability at the present time; but the actual excess of the mean density over the density of surface rocks, and the fact that a very large proportion of the land lies within a great circle having its centre in south-eastern Europe, suggest that the resistance to compression was once much smaller than it is now. This suggestion offers a possible dynamical explanation of the fact that the centre of gravity does not coincide with the centre of figure, and the maintenance of the Pacific Ocean on one side of the globe is due to the eccentric position of the centre of gravity.

The actual shape of the lithosphere, or rocky nucleus of the earth, and its situation relative to the geoid, or the equipotential surface which coincides with the surface of the ocean, are due to many causes, of which the eccentric position of the centre of gravity is one. Other important causes are the rotation and the attraction of the moon. The moon was once very near the earth, and the day and the month were once nearly equal. The earth was then drawn out towards the moon nearly into the form of an ellipsoid with three unequal axes. The direct result of the rotation and the attraction of the moon would be to give to the lithosphere the shape of an ellipsoid differing slightly from the ellipsoidal figure of the geoid. If the centre of gravity coincided with the centre of figure, the lithosphere would protrude from the geoid near the North and South Poles and in two equatorial regions at the opposite ends of the longest equatorial diameter of the lithosphere. If the density were in excess on one side of a diametral plane and in defect on the opposite side, the effects of the rotation, and of those irregularities of attraction which are due to the ellipsoidal figure, would be greater where the density was greater, and the surface of the lithosphere would consequently be deformed in such a way that the deviation from the ellipsoidal figure could be expressed mathematically by means of a spherical surface harmonic of the third degree. The ellipsoidal deviations from sphericity are expressed by harmonics of the second degree, and the eccentric position of the centre of gravity is equivalent to a deviation from symmetry expressed by harmonics of the first degree. We can therefore account theoretically for the presence of harmonics of these three degrees in the formula for the shape of the lithosphere and its situation relative to the geoid.

Now it is known that the actual contour-line at mean-sphere-level (1400 fathoms below sea-level) divides the surface of the globe into two regions of equal area—the continental block and the oceanic region. The continental block is practically continuous, and there are two great ocean basins, one containing the deep parts of the Atlantic and Indian Oceans, and the other the deep part of the Pacific Ocean. A spherical harmonic analysis of the distribution of land and water, account being taken of the submerged portions of the continental block, yields the result that the actual outlines of the great ocean basins at mean-sphere-level coincide very approximately with one of the contour-lines of a certain spherical harmonic containing terms of the first, second, and third degrees, but no terms of any higher degree.

It appears, therefore, that the shapes and relative situations of the great ocean basins, and their positions relative to the polar axis, can be described, at least approximately, in the statement that the lithosphere is an ellipsoid with three unequal axes, having its surface deformed according to the formula for a certain spherical harmonic of the third degree, and displaced as a whole relatively to the geoid in the direction towards south-eastern Europe. The displacement of the surface as a whole is accounted for by the eccentric position of the centre of gravity, and this eccentric position can be regarded as a survival from a past state in which the resistance to compression was too small for a spherically symmetrical configuration to be stable. The ellipsoidal figure is accounted for partly by the rotation and partly as a survival from a past state brought about by the attraction of the moon at the time when the day and the month were nearly equal. The deformation of the ellipsoid according to the formula for a spherical harmonic of the third degree is accounted

¹ Based upon a paper on "The Gravitational Stability of the Earth," by Prof. A. E. H. Love, F.R.S., read before the Royal Society on March 14.

for as being due to the interaction of the two causes which gave rise to the ellipsoidal figure and to the eccentric position of the centre of gravity. The main features of the existing division of the surface into continental and oceanic regions can thus be traced to the operation of simple dynamical laws.

PRESENTATION OF THE FREEDOM OF THE CITY OF LONDON TO LORD LISTER.

IN honouring Lord Lister on June 28, the City of London acknowledged the debt humanity owes to the conscientious man of science. Lord Lister was presented with the freedom of the City "in recognition of his eminence as a surgeon, and of the invaluable services rendered to humanity by his discovery of the antiseptic system of treatment in surgery, whereby so great a progress in surgical science has been achieved, so much suffering has been alleviated, and so many valuable lives have been prolonged."

The Lord Mayor attended in state, and among those invited to be present were the President of the Royal College of Physicians, the President of the Royal College of Surgeons, Sir Henry Roscoe and Dr. Charles J. Martin (representing the Lister Institute of Preventive Medicine), Sir F. H. Lovell and Sir P. Manson (representing the London School of Tropical Medicine), Sir Norman Lockyer (representing the British Science Guild), Sir Victor Horsley, Prof. Howard Marsh (University of Cambridge), Dr. L. W. Darra Mair (representing the Chief Medical Officer of the Local Government Board), Sir W. H. Broadbent, Sir William Collins, Sir Frederick Treves, and members of the medical staffs of several of the London hospitals.

Sir Joseph Dimsdale, the City Chamberlain, in admitting Lord Lister to the freedom, remarked:—

A century ago the Corporation of London paid her tribute of honour to the great professions of which Lord Lister is so bright an ornament. In 1803 the Freedom of the City was presented to Dr. Jenner, whose name will ever be associated with the discovery of vaccination, and whose researches superseded the system of inoculation—at that time so successfully and usefully employed to combat the dread disease of small-pox by such men as Dr. Fothergill and Dr. Dimsdale. To-day we meet to do honour to one whose life-long labours mark another epoch in the history of medicine and surgery. During the last half-century the strides made both in medicine and surgery have been little short of marvellous. What was impossible a few years back is now of daily and hourly occurrence. The treatment of disease—the safety in operations—and the careful and tender nursing of the patient are a few of the many developments of our time, and throughout this period Lord Lister has held a foremost place and has been recognised as one of the greatest and most prominent among surgeons. But it is not only as a great surgeon he is known. He is equally a great man of science, and it is by blending his antiseptic treatment with modern surgery that he has made possible so much that has—until lately—been impossible. He stands out as one who has been instrumental in assuaging suffering, lessening disease, and, under God's blessing, prolonging and saving numberless lives. Few are permitted to see the full fruition of their lofty aims and aspirations, but it is with sincere pleasure we greet Lord Lister in this ancient Guildhall, and rejoice to feel that he is able to enjoy the honours conferred upon him by his Sovereign—to be the recipient of universal expressions of esteem and admiration of his work from all seats of learning; while eulogiums from every quarter of the globe proclaim the appreciation the world in general feels for his life-long labours. It remains for posterity fully to gauge and comprehend the magnitude of the legacy he bequeaths to mankind. The City of London—and through her the country—places, I venture to think, the coping stone to-day to the monument of his fame. The citizens, in expressing their deep gratitude for his great services to the human race, ask his acceptance of the

highest honour it is in their power to bestow. But while they fully recognise his great work, probably the trait that touches the hearts of his fellow countrymen most is his abnegation of self, and his humble-mindedness, which, amid all his triumphs, recognises that it is under Divine blessing he has achieved so much. Well might Lord Lister in the autumn of his life take to himself the words of Lord Byron:—

No lengthen'd scroll, no praise-encumbered stone.
My epitaph shall be my name alone;
If that with honour fail to crown my clay,
Oh! may no other fame my deeds repay;
That, only that, shall single out the spot,
By that remember'd, or with that forgot.

The name of Lister requires no embellishment, nor is the sculptor's art needed to perpetuate it in posterity. So long as humanity exists, so long as kind and sympathetic hearts beat in the breasts of mankind, so long as the human race is capable of estimating the worth and value of the truly great and good, so long will the name of Lister live, and the memory of him who bears it remain enshrined and held in affectionate reverence by succeeding generations.

Lord Lister in reply said:—

I thank you, Sir Joseph Dimsdale, from the bottom of my heart for your overpoweringly kind words. The work which it has been my great privilege to be engaged in has been its own all-sufficient reward. Perhaps I need not say that I value in the highest degree this, the greatest civic distinction in the world. If it were possible to enhance the honour you have conferred on me to-day this has been done by the extraordinary consideration shown by you, my Lord Mayor, and your Court for my personal convenience. Had it not been for this your extreme kindness it would have been impossible for me in my very infirm state of health to have received your gift here in this historic building.

The 18-carat gold casket in which the freedom was contained bears the following inscription:—

Presented by
The Corporation of the City of London,
with the Freedom of the City,
to the Right Honourable Lord Lister, O.M., M.D., F.R.S.,
D.C.L., etc.,
in recognition of his eminence as a Surgeon and of the
invaluable services rendered to humanity by his discovery
of the Antiseptic System of Treatment in Surgery.
Guildhall, E.C., June 28, 1907.

The end panels are decorated with emblems relating to Lord Lister's career, and on the curve of the base a series of figures symbolising scientific research are embossed.

We welcome this well-deserved honour to science, and congratulate Lord Lister upon the latest distinction conferred upon him. Men of science are gratified that the Court of Common Council has shown in such an appropriate way its appreciation of the value of scientific research to the community.

THE EXTENSION OF THE BRITISH MUSEUM.

ON June 27 the King laid the foundation-stone of the new buildings forming an extension of the British Museum. A distinguished company invited to attend the ceremony included Lord Rayleigh, President of the Royal Society, Lord Avebury, Lord Kelvin, Sir John Evans, Sir Henry Howorth, Prof. E. Ray Lankester, Sir Norman Lockyer, and Sir William Ramsay. The Archbishop of Canterbury, as one of the three principal trustees, in his address to the King, detailed the circumstances which had made the extension possible. The origin of the scheme for the extension was described in the address as follows:—

Your Majesty has graciously conferred on the trustees of the British Museum a great honour in being present here this morning to lay the foundation-stone of this, the